



## Effectiveness of Flushing on Reducing Lead and Copper Levels in School Drinking Water

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The goal of U.S. EPA for lead levels in drinking water is zero (1) due to recent information linking relatively low blood-lead levels in children to deleterious effects on health and intelligence (2–9). Toward this end, EPA has developed an action level of 0.015 mg/l (in 1-l samples) for lead that water purveyors must meet to be in compliance with federal regulations (1). For schools, EPA recommends a lead action level of 0.020 mg/l in a 250-ml water sample. The action level for copper is the same as the maximum contaminant level goal (MCLG), which is 1.3 mg/l regardless of sample volume or location.

It is well established in the literature that lead and copper reach drinking water through the dissolution of plumbing materials (10–16) and that lead in water may influence blood-lead levels in humans (17–20). However, the leaching of these metals is unpredictable, and strategies for their elimination from drinking water have been difficult to develop and evaluate. This study focuses on quantifying the amount of lead in school drinking water fountains in New Jersey at different times during a typical school day. Data were examined to see if flushing in the morning is adequate to reduce lead and copper levels all day. Possible correlations between lead and copper levels and corrosivity were also investigated.

Two drinking water fountains in each of 50 school buildings were sampled in 1991–1992. Fountains were selected to represent one high-use and one low-use fountain. This process assured representativeness of the fountains to eliminate the possibility of selecting only remote or only often-used fountains, as it was impossible to quantify the water use during the hours between the first-draw samples and the lunchtime samples.

Water samples were collected from the two drinking water fountains first draw, after a 10-min flush, and at lunchtime (just before the school's first lunch break, approximately 3–5 hr after the first-draw samples). Temperature and pH measurements were taken at time of sampling. The Bureau of Radiation and Analytic Services at the New Jersey Department of Environmental Protection and Energy conducted metals analysis using standard furnace atomic absorption EPA Methods 239.2 for lead and 220.2 for copper and using approved methods for alkalinity (21) and hardness (22). Appropriate quality control/quality assurance samples included blanks, spikes, and duplicates. Blind split samples were sent to the Rutgers University Chemistry Department to check accuracy of the analyses. Data were analyzed, sorted, and subjected to the Mann-Whitney two-sample, nonmatched test for nonparametric distributions to determine significant differences between populations using an  $\alpha$  level of 0.05.

Samples from drinking water fountains in 50 schools in New Jersey were collected at specific times during a typical school day and analyzed for lead, copper, pH, alkalinity, and hardness. First-draw lead and copper levels (medians 0.010 mg/l and 0.26 mg/l, respectively) decreased significantly after 10 min of flushing in the morning (medians 0.005 mg/l lead and 0.068 mg/l copper), but levels increased significantly by lunchtime (medians 0.007 mg/l lead and 0.12 mg/l copper) after normal use of fountains in the morning by students. Corrosive water, as defined by the aggressive index, contained significantly higher levels of lead and copper (medians 0.012 mg/l and 0.605 mg/l, respectively) than noncorrosive water (medians 0.005 mg/l and 0.03 mg/l, respectively). **Key words:** corrosivity, drinking water, flushing, lead, water. *Environ Health Perspect* 101:240–241(1993)

**Table 1.** Distribution of lead and copper concentrations in school drinking water

	First draw	10-min flush	Lunchtime
Lead, range (mg/l)	BD–0.135	BD–0.074	BD–0.075
Lead, median	0.010 <sup>a</sup>	0.005 <sup>b</sup>	0.007 <sup>c</sup>
Copper, range (mg/l)	BD–10.2	BD–7.8	BD–8.5
Copper, median	0.26 <sup>a</sup>	0.068 <sup>b</sup>	0.12 <sup>a</sup>
pH, range	4.1–8.7	5.0–7.9	4.4–8.8
pH, median	7.1 <sup>a</sup>	7.1 <sup>a</sup>	7.0 <sup>a</sup>
Temperature range (°C)	9.0–33	9.0–28	9.0–33
Temperature median (°C)	20 <sup>a</sup>	20 <sup>a</sup>	17 <sup>a</sup>
No. of samples	101	100	100

BD, below detection. Medians with the same letter within a row represent populations that are not significantly different at the 0.05 level as determined by the Mann-Whitney two-sample, nonmatched test for nonparametric distributions.

**Table 2.** Distribution of lead and copper concentrations according to corrosivity of water samples

Sample	Lead (mg/l)		Copper (mg/l)		No. of samples
	Range	Median	Range	Median	
Corrosive	BD–0.074	0.012 <sup>a</sup>	BD–10.2	0.605 <sup>a</sup>	98
Moderate	BD–0.135	0.006 <sup>b</sup>	BD–2.15	0.092 <sup>b</sup>	164
Noncorrosive	BD–0.019	0.005 <sup>b</sup>	BD–0.36	0.03 <sup>c</sup>	30

BD, below detection. Medians with the same letter within a column represent populations that are not significantly different at the 0.05 level as determined by the Mann-Whitney two-sample, nonmatched test for nonparametric distributions.

utions to determine significant differences between populations using an  $\alpha$  level of 0.05.

The distribution of the data according to the time of day the samples were taken is shown in Table 1. The highest overall lead and copper levels were in first-draw samples. These medians were significantly different from median concentrations in the 10-min flushed samples (Table 1). Lunch-time samples contained significantly more lead and copper than flushed samples. For copper, the lunchtime median (0.12 mg/l) was statistically identical to the first-draw median (0.26 mg/l), indicating that copper levels increased to first-draw levels after normal use of fountains in the morning. For lead, this pattern was also apparent; however, the lunchtime median (0.007 mg/l) was not statistically identical to the first-draw median (0.010 mg/l).

Neff et al. (14) observed significant leaching of metals from plumbing materials in waters considered corrosive according to the Langelier index. Kish et al. (23) showed that the aggressive index (AI) can be used as effectively as the Langelier index to predict the corrosivity of water. These researchers showed that water with an AI <10 (consid-

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**Table 3.** Distribution of lead and copper concentrations in corrosive, moderately corrosive and noncorrosive water according to time of sample

Sample	Lead (mg/l)		Copper (mg/l)		No. of samples
	Range	Median	Range	Median	
First draw					
Corrosive	BD–0.071	0.015 <sup>a</sup>	BD–10.2	1.01 <sup>a</sup>	35
Moderate	BD–0.135	0.008 <sup>b</sup>	BD–2.15	0.14 <sup>b</sup>	52
Noncorrosive	0.003–0.021	0.010 <sup>a,b</sup>	BD–0.36	0.11 <sup>c</sup>	12
10-min flush					
Corrosive	BD–0.074	0.008 <sup>a</sup>	BD–7.8	0.34 <sup>a</sup>	33
Moderate	BD–0.033	0.005 <sup>a</sup>	BD–1.53	0.05 <sup>b</sup>	49
Noncorrosive	BD–0.013	0.003 <sup>a</sup>	BD–0.13	0.004 <sup>c</sup>	16
Lunchtime					
Corrosive	BD–0.065	0.013 <sup>a</sup>	BD–8.5	0.67 <sup>a</sup>	33
Moderate	BD–0.75	0.005 <sup>b</sup>	BD–1.64	0.06 <sup>b</sup>	55
Noncorrosive	0.002–0.018	0.006 <sup>a,b</sup>	BD–0.16	0.06 <sup>b</sup>	10

BD, below detection. Medians with the same letter within a column represent populations that are not significantly different at the 0.05 level as determined by the Mann-Whitney two-sample, nonmatched test for nonparametric distributions.

ered corrosive) was more likely to leach plumbing metals into water than water with an AI >10. The AI is calculated using the equation

$$AI = pH + \log [(total\ alkalinity) \times (calcium\ hardness)].$$

The data presented in Table 2 show that corrosive water (AI <10) contained significantly higher lead and copper levels than moderately corrosive (10–11.9) or noncorrosive (≥12) water. Table 3 breaks down the data further according to time of day the sample was collected. Corrosivity did not affect lead levels in the 10-min flushed samples, although it did affect copper levels. For first-draw and lunchtime samples, lead concentrations in corrosive water (0.015 mg/l first draw; 0.013 mg/l lunch) were significantly different from those in moderately corrosive water (0.008 mg/l first draw; 0.005 mg/l lunch), but not different from noncorrosive water (0.010 mg/l first draw, 0.006 mg/l lunch). Some first-draw water samples containing elevated lead levels were noncorrosive according to the AI. Corrosivity, although helpful in predicting a building's vulnerability to leaching of lead to drinking water in first-draw samples, is not the only parameter of importance. The amount of time the water is left standing in the plumbing system is significant when sampling first draw. Even noncorrosive water may leach lead from plumbing if it remains in contact with the plumbing materials a sufficient length of time. On the other hand, copper concentrations differed significantly with corrosivity at all sample times, indicating a direct correlation between copper levels and water corrosivity (Table 3).

The most significant observation from this study is that one-time, morning flushing of schools' drinking water may not provide day-long protection for children. Schools currently using flushing as a temporary remedy to control lead exposure to students

should consider periodic flushing; that is, running drinking water fountains for 5–10 min every 2–3 hr during the school day. Longer flushing may be needed in the mornings, after vacations, weekends, and holidays. Officials in Maryland have also demonstrated problems with once-a-day flushing programs in schools (24). Despite this knowledge, schools continue to flush once in the morning to reduce lead levels. It is up to regulators in the states to educate school administrators about proper flushing procedures.

Although many states have initiated aggressive sampling campaigns for schools (2,24), many advocate sampling once in the morning to assess lead levels in drinking water. It is important that school drinking water be monitored for metals that may leach from plumbing and that samples be taken first draw, after a flushing period, and at some point during the school day. In this way, school administrators can determine if a potential lead or copper problem exists, whether flushing can alleviate the problem for day-long protection, and what the source of contamination is. Once this information is available, school officials can take action to remove or ameliorate the problem.

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